Economic Analysis Contest Activity Details

In this Contest Activity, teams are required to do the following:

1. Generate a realistic cost estimate for a marketable prototype version of the competition house
2. Present the results of an analysis justifying the economic benefits of the building integrated photovoltaic (BIPV) solution(s)
3. Use building energy optimization techniques to identify a suite of economically-appropriate energy-efficiency measures (EEMs) that may be used to inform design decisions.

Marketable Prototype Cost Estimate

Assume that this estimate is part of a bid package submitted to a client interested in purchasing a marketable prototype version of the competition house. The team should think of itself as a homebuilder assembling a bid for a client within the team's target market. The "competition house" is the house a team brings to the competition. A "marketable prototype" is a hypothetical version of the competition house. Some marketable prototype costs may be lower than the competition house costs, because systems and features that may have been custom designed for the competition house are assumed to have become commercially available. In this case, teams shall document the rationale for cost decreases. Specific instructions follow:

- Estimates shall be organized according to the 2004 MasterFormat standard.
- Teams may use the software package of their choice for cost estimating and reporting purposes.
- Teams may use the cost database of their choice to estimate unknown costs.
- Teams are encouraged to consult a book, such as Wayne J. DelPico's *Estimating Building Costs*, published by RSMeans, or consult with a professional cost estimator to get a feeling for the types of information and level of detail in a typical cost estimate. Note that materials estimates are only one of several components of a typical cost estimate.
- The Organizers will use the building cost estimate to create a "Product Directory" for the general public. The 2005 Solar Decathlon Product Directory can be accessed on the Web. To facilitate the development of the Product Directory, the cost estimate shall include all information that a member of the general public would need to purchase a product for his or her own do-it-yourself project. Ordinary parts, such as nuts and bolts, that can be purchased at any hardware store or home center are excluded from this requirement.
- The "Procurement and Contracting Requirements" division (Division 00) of the 2004 MasterFormat standard need not be included in the estimate.

BIPV Economic Analysis

In his 2006 State of the Union Address, President Bush introduced the Solar America Initiative (SAI). The primary goal of the Initiative is to make the cost of solar-generated electricity competitive with the cost of electricity generated with conventional energy sources. Because BIPV systems have the potential to reduce the effective cost of a PV system by reducing or eliminating the costs of the building components they replace, BIPV is expected to make a major contribution toward the initiative's cost-reduction goals for systems installed on residential and commercial buildings.

Teams are challenged to utilize existing BIPV equipment and design solutions or to develop new equipment and solutions (or both) to reduce the levelized cost of energy generated by their PV systems ($LCoE_{PV}$). To justify their BIPV approaches, teams are required to use a PV simulation tool and the LCoE calculator to determine the $LCoE_{PV}$ in Phoenix,Arizona, Washington, D.C., and a third location of the team's choosing. If the economic analysis was optimized for a particular location, that location should be chosen as the third location.

The Economic Analysis Jury will assign the highest scores to teams whose BIPV designs most effectively reduce the $LCoE_{PV}$. The Jury will not base its decision solely on the reported $LCoE_{PV}$, because the $LCoE_{PV}$ can be affected by factors unrelated to the effectiveness of the BIPV design. Creativity and market potential of the BIPV design will be emphasized more heavily than reaching a low $LCoE_{PV}$, if the low cost is not primarily attributable to the BIPV design.

Procedure for calculating the $LCoE_{PV}$ using the LCoE Calculator:

1. Enter cost and rating information in the first five green cells.
2. Enter the results of the annual PV simulation into the green "PV system energy production in 2007" cell. Note that the PV de-rating factor shall be included in the team's simulation.
3. Choose a location that matches the simulation location.
4. Record the $LCoE_{PV}$, which is located in the "Marketable Prototype" box.

EEM Economic Analysis

A critical long-range outcome of the Solar Decathlon project is the development and demonstration of solar-powered homes in which, by the year 2015, the whole-house, levelized energy cost has been reduced to $0.10/kWh, while complying with the criteria associated with the ten contests that make up the competition. Teams are encouraged to work toward this goal by identifying EEMs through the use of building energy optimization methods (a paper describing one building energy optimization method is posted on the Yahoo! Group) and by using the results of their building energy simulations and building cost estimates to calculate the whole-house levelized energy cost ($LCoE_{WH}$) for benchmarking purposes. The $LCoE_{WH}$s calculated by the 2007 teams will be compared to the $LCoE_{WH}$s of future Solar Decathlon teams to determine whether DOE's long-range objectives are being met.

For this contest activity, teams are required to summarize their building energy optimization results and explain how the optimization results were used to inform design decisions. The Economic Analysis Jury does not expect teams to always choose the most economically appropriate designs and equipment. Sound economic decisions do not necessarily equate to sound competition decisions because of the peculiarities of the competition. Therefore, the calculation of an *accurate* $LCoE_{WH}$ is more important than the calculation of a *low* $LCoE_{WH}$. Likewise, it is more important that teams use building energy optimization methods to recognize and identify the economic ramifications of available design and equipment options than it is for them to actually choose the most economical option.

Procedure for calculating inputs for the blue cells in the LCoE calculator:

1. Define a benchmark version of the marketable prototype house using the Building America Analysis Spreadsheet. The definition of a "minimum physical" benchmark is more realistic and, therefore, preferable to, a benchmark defined exactly according to the outputs of the spreadsheet. A minimum physical benchmark, for example, would have R-13 walls instead R-11.7485 walls even if the spreadsheet suggests R-11.7485 walls because R-13 insulation is actually available on the market and R-11.7485 isn't. Refer to the Building America Research Benchmark document for more information about the benchmark definition.
2. Use a reputable hourly simulation tool, such as DOE-2, Energy Plus, TRNSYS, or others, to project the gross annual electricity load of both the benchmark and marketable prototype (can be net positive or net negative) houses in Phoenix, Arizona, Washington, D.C. (use the Sterling, Virginia weather file if the Washington, D.C. weather file is unavailable), and a third location of the team's choosing. If the economic analysis was optimized for a particular location, that location should be chosen for the third weather file. Download the Building America House Performance Analysis Procedures document for more information about modeling the Building America benchmark and the marketable prototype houses.
3. Estimate the first costs and operation and maintenance costs of all building components for the benchmark and marketable prototype houses that contribute to the difference in energy performance between the two houses (do not include the installed PV system costs; they are considered in the green cells in the LCoE calculator). The difference between the benchmark and marketable prototype costs are called the "incremental" costs. The approach used to generate the Marketable Prototype Cost Estimate should also be used for the benchmark house.
4. Enter the following inputs into the LCoE calculator:
    - Incremental cost of house components affecting energy performance [US dollars (US)]; includes installation, permitting, and other associated costs
    - Annual gross (utility-billed) electricity load of benchmark (kWh/yr)
    - Annual gross (utility-billed) electricity load of prototype (kWh/yr); does not include energy generated by the PV system
    - Annual electricity generated by the PV system (kWh/yr)
    - Annual incremental (i.e., marketable prototype minus benchmark) operation, maintenance, and equipment replacement cost of building components affecting energy performance that are not part of the PV system (USD/yr).
5. Record the $LCoE_{WH}$, which is located in the "Marketable Prototype" box.

Assumptions, guidelines, and requirements for BIPV and EEM Economic Analyses

- The benchmark and marketable prototype houses must be all-electric, grid-tied, and net-metered.
- Justify significant assumptions and simplifications
- If custom equipment is used in the marketable prototype, the cost should be based on the sum of the equipment components' parts, unless teams can justify and document a rationale for a lower cost after the equipment becomes commercialized.
- The energy simulation results used in the economic analysis must be consistent with results presented in the Energy Analysis Reports. Teams are encouraged to use and cross-reference the energy analysis results in the economic analysis.
- If the design has been optimized for one of the three modeled locations, indicate which location in the report. The Economic Analysis Jury will take this into consideration, when it evaluates the results at the other two locations.
- Use constant 2007 USD in the analysis
- Assume that the car is driven 50 miles per week and requires a 0.2-kWh charge per mile driven. As it evaluates the effect of energy production capacity on $LCoE_{WH}$, the Jury will be mindful of the possibility that many teams oversized their energy production capacity (and storage) for competition purposes.
- The benchmark and marketable prototype computer models should reflect the expected house configuration in its final installed location. This may affect foundation, energy storage, and other parameters that are likely to change between the competition and the final installation.
- The following financial parameters are consistent with DOE assumptions and are fixed in the LCoE Calculator:
    - Analysis period: 30 years (Jan 1, 2007 through Dec 31, 2036)
    - Inflation rate: 2.5%
    - Real discount rate: 5.5%
    - Federal tax: 28%
    - State tax: varies by state (see LCoE calculator)
    - Debt: 100% of installed system cost and 100% of incremental cost of EEMs
    - Term: 30 years
    - Rate: 6%
    - Price of purchased electricity:
        - Phoenix, Arizona: $0.078/kWh
        - Washington, D.C.: $0.074/kWh
        - Third location specified by team: varies by state (see LCoE Calculator)
    - Property tax: None
    - Insurance: None
    - Depreciation: None
    - Financial incentives: None.

- The following PV system performance parameters are consistent with DOE assumptions and are fixed in the LCoE Calculator:
  - PV system derating factor (apply to the PV system simulation): 5%
  - PV system degradation: 1% per year.

Format Requirements

- There are no restrictions on the software tools that can be used for this Contest Activity, but all tools should be clearly identified.
- One electronic copy (Microsoft Word document or Adobe PDF for reports and Microsoft Excel for cost estimate) of each deliverable must be uploaded to the appropriate team folder on the Solar Decathlon FTP site (ftp://ftp.nrel.gov/pub/solar_decathlon/Team_Folders/) or e-mailed directly to Mike Wassmer at sdrules@nrel.gov on the respective due date by 5 p.m. mountain time. Points will be deducted for lateness. Please contact Mike Wassmer at sdrules@nrel.gov as soon as possible, if the chosen cost estimating software cannot export to Microsoft Excel.
- The Preliminary Economic Analysis Report (due June 13, 2006) shall include BIPV and EEM Economic Analyses results and discussion as of June 13, 2006. The main body of the report may not exceed 15 single-sided pages, using a single-spaced 11-pt font. The pages must be 8.5 in. X 11 in. (or closest metric equivalent) and may include any embedded graphics that are appropriately placed in the body of the report. Appendix material (e.g., data sheets, simulation results, and screen captures) may be included, if desired. The appendix shall have the same format as the body of the report and may not exceed 15 pages.
- The Final Economic Analysis Report (due August 7, 2007) shall include final BIPV and EEM Economic Analyses results and discussion. It will be evaluated and scored by the Economic Analysis Jury. The main body of the report may not exceed 25 single-sided pages, using a single-spaced 11-pt font. The pages must be 8.5 in. X 11 in. (or closest metric equivalent) and may include any embedded graphics that are appropriately placed in the body of the report. Appendix material (e.g., data sheets, simulation results, and screen captures) may be included, if desired. The appendix shall have the same format as the body of the report and may not exceed 25 pages.
- Each version of the cost estimate should get more detailed as the design is developed, and the building is constructed. All cost estimates should reflect the marketable prototype version of the house, not the competition house. In some cases, the marketable prototype and competition house may be significantly different. The purpose of first Cost Estimate (due June 13, 2006) is to ensure that teams have begun estimating costs for the building presented in the Design Development Drawings and Specifications. The Organizers will verify that the data is organized according to the MasterFormat standard and that the software package being used to generate the estimate is appropriate and capable of exporting to Excel. The second Cost Estimate (due March 6, 2007), third Cost Estimate (due August 7, 2007), and fourth Cost Estimate (due January 9, 2008) are expected to be significantly more detailed than the first Cost Estimate, because they are due after the design has been completed and construction has begun. Each subsequent version of these cost estimates is a refinement of the previous one and should reflect changes that have occurred between the respective deadlines. Note that only the third Cost Estimate will be evaluated by the Economic Analysis Jury.